The revolution. Is it coming? Is it here? Is it over? Well, there certainly is something happening, and From Animals to Animats 2: Proceedings of the Second International Conference on Simulation of Adaptive Behavior is self-consciously and aggressively related to that something, whatever it is. "On December 7–11, 1992, in Honolulu, Hawaii, just steps from Waikiki Beach, 125 researchers from Europe, North America, and Japan met to report from, debate, and push forward the frontier of an exciting new approach to understanding intelligence: the simulation and building of artificial animals (‘animats’) which must survive and adapt in progressively more challenging environments. Representing fields as diverse as ethology, psychology, connectionism, evolutionary computation, and robotics, the participants shared the belief that the creation of whole, coping, animal-like systems—however simple at the moment—may be one of the best routes to understanding intelligence in both natural and artificial systems. . . . These proceedings contain 59 papers and constitute the most comprehensive and up-to-date source on the field." They also cost $55, in paperback. And the "just steps from Waikiki" somehow encapsulates the whole thing, for me at least. I’ve never been to Waikiki, but the images it calls up in me are a wonderful mélange of dynamism and tackiness: a breathtaking landscape appreciated by some but also littered with (and by) others who won their trip in a lottery and are so preoccupied by their own concerns that they might as well be in Hoboken, a richly expansive state of mind crosscut with traces of snobbishness associated with having made it to a place the reaching of which is an end in itself, an undeniably beautiful and fertile place that somehow just doesn’t connect well to the rest of the world.

From Animals to Animats 2 isn’t going to persuade any skeptics that a revolution is imminent, much less that it is over. Multidisciplinary, yes. Coherent, no. The vast majority of the papers are narrowly focused reports of not very closely related inquiries whose connectedness relates to a shared faith (or an assertion of faith) in a particular approach to artificial intelligence, but whose origins are in particular problems of particular disciplines. And it is not only their origins that are there. By and large, one needs to be both one of the converted and interested in the disciplinary problem to find most of the papers at all compelling and even then there is a curious sort of playing both ends against the middle (for disciplinarians: “the important thing here is that I’m attempting a theoretical approach,” for theoreticians: “keep in mind that I’m dealing with an important disciplinary problem”). Which is to say that an unreasonable number of the papers do not get anywhere very much on their own. A reader has to care about the revolution, and be curious about whether the whole is greater than the sum of the parts. There are, however, exceptions, including a nice introductory paper laying out the distinction between traditional “knowledge-based” artificial intelligence and “behavior-based” AI, the latter being the hoped-for unifying theme (I’ll get back in a bit to the distinction, which I think is a good one). A few other papers also stand on their own, and it is noteworthy that these, like the introductory paper, are unusually frank in admitting that what is going on is very much a work in progress, one whose justification has more to do with a newly discovered and legitimated freedom to play than it does with any certain route to the solution of problems currently in the bailiwick of existing disciplines.

So, is there a revolution? And, if so, what it is about, what stage is it in, and how does From Animals to Animats 2 relate to it? Yes, of course a revolution has begun. Anyone skeptical of this should read Daniel Dennett’s Consciousness Revealed (ignore the title) or Stuart Kauffman’s Origins of Order, two recent more compelling artifacts of the revolution. Both shed new light on old and neglected problems by suggesting that aspects of observed order in complex systems need reflect neither a designer outside the system nor an identifiable and isolatable master element within the system, that interesting and significant order may instead emerge simply from the relatively local interactions of a large number of relatively simple elements. "Simply" means in the absence of the aforementioned; it most emphatically does not mean "trivially." Dennett and Kauffman stand on the shoulders of others who had the courage to be interested in the consequences of relatively simple interactions not because they had any particular likelihood of explaining anything known but rather because they seemed to have surprisingly complex outcomes. That this has proven to be robustly and generally so has created a new mindset that is impacting dramatically on a variety of disciplines, not so much because it is the key to existing accepted disciplinary problems (though it has caused a number to be seen in a new way) as because it suggests ways to differently and usefully approach problems that seemed previously to have been proven more or less unapproachable.

The new mindset, associated with terms like “chaotic systems,” “parallel and distributed processing,” “interaction dynamics,” and “emergent properties,” has long since proven its worth in cognitive neuroscience (see Dennett, for example), and elsewhere. And by the very nature of the revolution there is more, almost certainly a lot more, yet to come. We seem, as suggested by others,
to be on the verge of a new science, a science of complex systems, one that will both contribute to and draw from cognitive neuroscience. For fascinating historical and cultural reasons, an enormous landscape of potentially meaningful observations, previously unexplored, has suddenly been opened up. It is, at the moment, quite literally true that almost anyone with curiosity (it will help to have a computer) can come up with significant and novel observations, as did the pioneers of the revolution, simply by exploring the patterns of organization that emerge from some as yet unexplored set of simple interactions. That this is so is both a statement about where we are in the revolution and an indication of its potential payoff. We have some intuitions about the behavior of complex systems (represented in, among other places, "folk psychology"), but nowhere near the kind of understanding that would allow formal statements about the explanatory power and limitations of this approach, and the only way to get closer to that kind of understanding is (as with all science) by making the relevant observations. What is exciting about the possible payoff is that the relevant observations are, by their very nature, quite general. The intuitions, and ultimately the elaborated theory if it comes successfully into being, will relate not to particular situations but rather to all instantiations of phenomena that fundamentally arise from the diverse interactions of diverse elements. The relevance to cognitive neuroscience is obvious, as are the contributions that cognitive neuroscience (and neuroscience generally) has made and will continue to make.

*From Animals to Animats* 2 is a peripheral rather than a central artifact of the ongoing revolution. The distinction between the more classical "knowledge-based" AI and the "behavior-based" AI championed by the volumes corresponds roughly to the absence or presence of a central controller into which one attempts to put enough information to deal with all possible contingencies. Can one get "intelligent," perhaps even "more intelligent" behavior by hooking together sets of fairly stupid components and relying on their interactions with each other and the world? Does it tell us anything about natural intelligence? Yes, and maybe, and not a lot yet are the bottom line answers one gets from *From Animals*. But this is neither worth $55, nor entirely fair to the book. Of course one can get "more intelligent" behavior by hooking together sets of fairly stupid components and relying on their interactions with the world. At least one can if one regards living organisms (humans included) as "more intelligent" and believes in evolution. Can it be done in less than five billion years and yield insights along the way? I'm optimistic, glad to discover that people are trying and to know a bit about the details of what they are doing. It may well be that one or more of the approaches described in *From Animals* will evolve to justify my optimism, perhaps in major ways. After all, the revolution has just gotten started, the field is wide open, and building robots without knowing exactly what they are going to do is very much a part of it.

At the same time, the editors and authors of *From Animals* could have done a much better job of selling their wares. Evolution too is a dynamic interaction of diverse components in the absence of a central controller, one in which the interactions are as important as the properties of the elements. Both the editors and the authors of *From Animals* miss this point. The editors' tendency to portray *From Animals* as being itself the revolution, instead of one component of a larger revolution, and a corresponding propensity of the authors to cite previous publications easily accessible only to the "animat" community, cannot but lessen its impact. And then there is the matter of the revolutionary fervor of the whole crosscut with timidity in the details. If we are going to have a revolution, let's have one. By all means, let's boldly go where no man (or woman) has gone before. Boldly. And together.

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